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PEATLAND INVENTORY OF MANITOBA

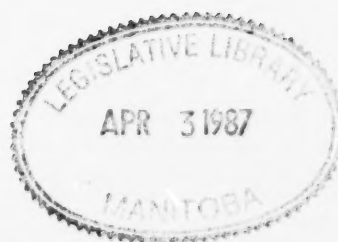
II—S.E. MANITOBA

Using LANDSAT

Manitoba
Natural Resources
Surveys and Mapping



December, 1986



PEATLAND INVENTORY OF MANITOBA

II - S. E. MANITOBA

USING LANDSAT

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ABSTRACT

The type, area and quality of peatlands in southeastern Manitoba are defined as a prerequisite for determining their potential for fuel, horticulture, agriculture and forestry.

The study area is located in the southeast of Manitoba between latitudes $49^{\circ} - 50^{\circ}21' N.$ and longitudes $95^{\circ} - 96^{\circ}10' W.$ A supervised classification technique was used to analyze two computer compatible tapes for Tracks 29 and 30 on the 11th July and 6th September, 1984, respectively. The results indicate the following correct proportional representation for each of the four vegetation types: Treed bog (83.2%), Shrub Fen (73.4%), Ericoid Bog (100%), and Sedge Fen (75.8%). The Shrub fen class was confused with treed bog (40 out of 444 sites) and with sedge fen (28 out of 139 sites). Ericoid bog was not confused with any other theme because of its small area and unique spectral reflection.

Satellite remote sensing of peatland vegetation, combining manual and machine interpretation of data, provides an estimate of areal extent of commercially exploitable peatlands but only a very approximate correlation with peat depths.

ACKNOWLEDGEMENTS

The continuation of this project, which uses LANDSAT imagery for a peatland inventory of Manitoba, was made possible through the efforts of W. G. Best, Chief of the Manitoba Remote Sensing Centre and D. Watson, Peat Coordinator for the Manitoba Department of Energy and Mines. Special thanks are due to Fisons-Western Corporation and Premier Peat Moss Ltd. for the cooperation of their staff on the ground surveys. Appreciation is extended to Gloria Kehler of the Department of Botany Herbarium, University of Manitoba, for the identification and confirmation of vascular plant species; and Kathryn Gilbertson who assisted in the field collection of ground truth information. Special thanks to Betty Sidoryk, Manitoba Remote Sensing Centre, for her patience in typing this report.

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1.0 INTRODUCTION

1.1 Background

Part of the mandate of the Manitoba Department of Energy and Mines is to define the abundance and areal extent of peatlands with commercial potential in Manitoba. The purpose of such a survey is in keeping with the overall integrated resource management strategy of the provincial government.

During 1983/84, a 'quick-look' inventory of The Pas mapsheet (53° - 54° N. and 100° - 102° W.) was undertaken using an interactive digital image analysis system called the Applied Resources Image Exploration System (ARIES-II, Dipix Ltd.). LANDSAT II multispectral data were classified by a supervised classification technique from one computer compatible tape, Path 37, RW 22, June 26, 1981 (Dixon and Stewart, 1984). The results confirmed what other observers (Pala, 1982; 1983; Stove, 1983; Palylyk, 1985) had described; and provided an areal estimate of the peatland classes - treed bog, shrub-treed fen and graminoid-rich treed fen. A major difficulty experienced by Dixon and Stewart (1984) was the spectral confusion between the fen classes from surface water reflectance which increased the probability of either multiple classifications or misclassifications of cover types. This spectral confusion of vegetation cover types restricted signature extension as

a method of large area inventory from single date imagery. To partly overcome some of these difficulties they proposed that a multi-date image analyses be attempted.

1.2 Resource Issue

The peat resources of Manitoba are considerable in both extent and quality of commercial grade horticultural peat moss (Bannatyne, 1980). Over 20,600,000 hectares or 38% of the provincial land base is estimated to contain peat deposits which in turn are estimated to equal 19% of the total peat resources of Canada (Mills, 1983). Most of Manitoban peatlands have not been evaluated because of accessibility, especially in the north and northeastern half of the province. One approach to evaluate Manitoban peatland resources is to have a reconnaissance survey using satellite imagery for the identification of large peatlands (> 200ha) and, when economic necessity dictates, follow with a detailed inventory of the selected peat deposits after the established procedures of the Canada-Manitoba Soil Survey (Tarnacoi and Stewart, 1986). Such an approach would enhance the accuracy, economy and efficiency of our peatland inventory for either geotechnical, agricultural, forestry, wildlife habitat and conservational uses.

1.3 Classification Issue

Classification systems of natural resources reflect the individual approaches and biases of the different

investigators. Each researcher approaches the peatland landscape units differently, consequently the proliferation of terms and classifications are often confusing since many differ from each other by subtle shades of interpretation. Hence, there is a need for a system of peat landform classification which is compatible to multi-users and verifiable by airphoto and ground-checking (Tarnocsi, 1970; Zoltai, et al. 1972; Mollard and Janes, 1984).

Classification is, by definition, hierarchical in structure often descending from a generalized to a specific level. The classification of peatlands - because of the vastness of Canada - must be flexible to accommodate the regional differences which influence the classifying of definitive units, e.g. oceanic vs. continental bogs. Peatlands are most often divided into two classes: bogs and fens. Bogs are wetlands with acid peat in a nutrient-poor (ombrotrophic) environment and characterized by acid tolerant vegetation such as Sphagnum, ericoids and with or without black spruce or tamarack. Fens in contrast, are formed in an environment relatively rich in nutrients (minerotrophic) and covered by a variety of sedges and grasses, feather mosses, low shrubs of willows or bog birches, tamarack and the occasional stunted black spruce.

The vegetation of peatlands is a function of the interplay between such factor-complexes as climate, topography, geological substratum and organisms, all operating within a time gradient. The combination of high

water table with resultant peat build-up gives rise to a specialized vegetation, relief, and hydrology which allows for classification by grouping peat-forming units of similar spectral reflectances. Such classifications depend on both biotic and abiotic elements. The biotic element uses vegetation to classify peatland surface phenomena by either floristic, physiognomic or dominance criteria. These differences are often reflected in the underlying peat. Floristic classification depends on the identification of plant communities based on species composition and abundance. In contrast, physiognomic and dominant classification emphasize the relative proportions of life-form spectra. The abiotic basis of peatland classification is best seen in the landform approach of Tarnacoi (1974), Zoltai et al. (1978) and Heinselman (1970, 1974). Radforth (1969) used airform patterns and vegetation cover to classify organic terrain or 'muskeg'. It is our intention to use dominant and floristic criteria to define the bog and fen classes before undertaking the supervised classification based on the physiognomic attributes of the spectral signatures from each class. The resolution of the clustered signatures for each class into indentifiable peatland types is the primary aim of this project.

1.4 Objectives

The goals of this project are:

1. To interpret the LANDSAT imagery of S.E. Manitoba

(52E and L, and 62H and I NTS map series) in terms of the bog and fen classes in this region. Training areas are located in representative bog and fen type which are reasonably accessible for ground-checking.

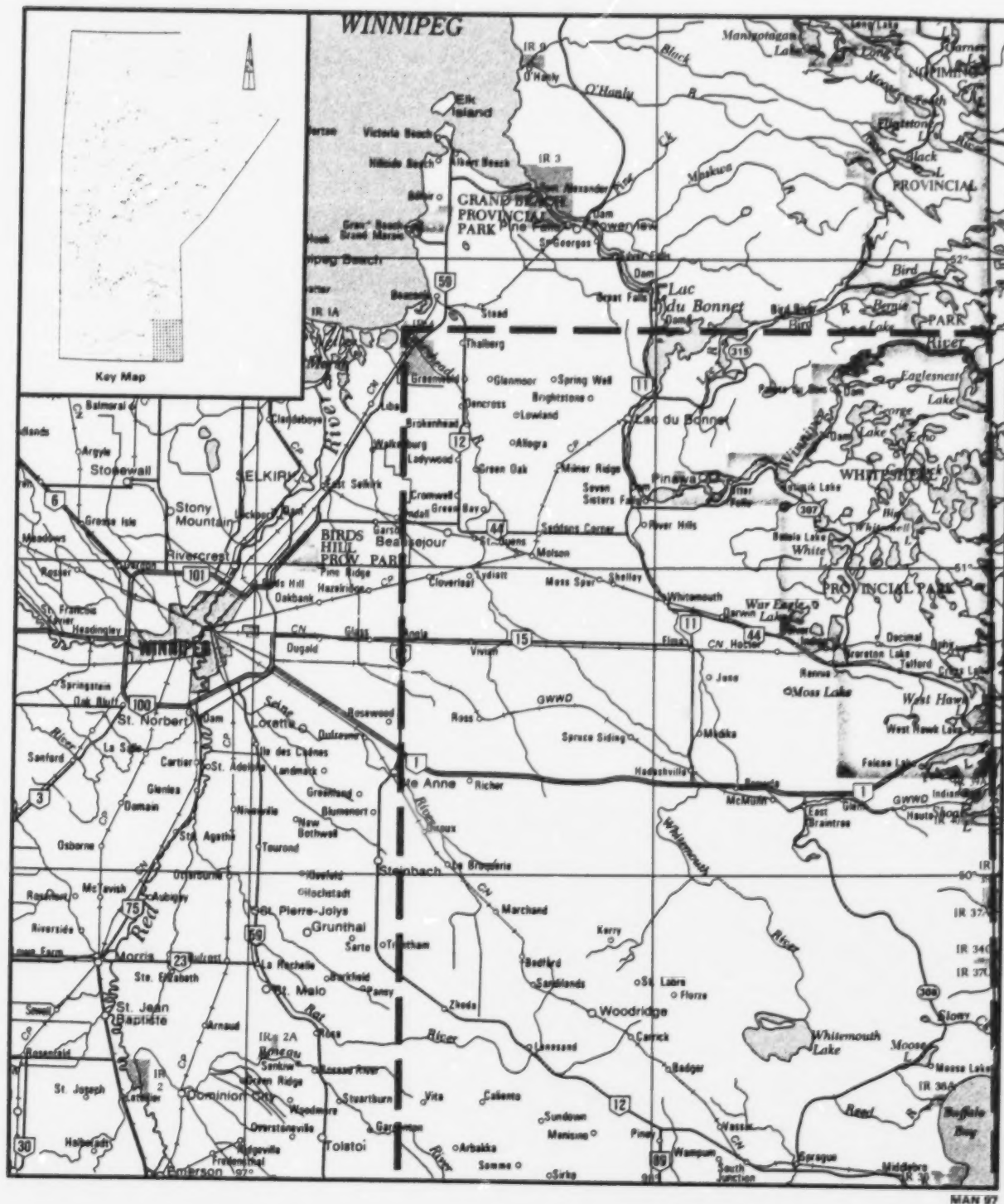
2. To produce a bog and fen vegetation cover map for approximately 12,500 square kilometers of the S.E. Manitoba map sheets at a scale of 1:125,000 from LANDSAT IV imagery. Additionally, the training sites in this region are assessed and verified using aerial photography and ground-truthing.

3. To determine if a relationship exists between peat depths and surface reflectance themes in order to rank the bogs and fens for commercial development.

2.0 STUDY AREA

2.1 Location

The peatlands involved in this study lie in the southeastern corner of Manitoba between the 49° and 50° 21' N. and between longitudes 95° W. and 96° 10' W. (Fig. 1). This study area covers 6 map sheets which includes townships 0 to 17 N. and ranges 17 to 6E., an area of approximately 12,500 km .



2.2 Climate

Weir (1980) simplified the study area into two broad climatic regions - 4H and 4G. The southeastern corner (4H - 2750 degree days, 0.0mm water deficiency and 381mm precipitation, May to September) represents a milder climate with an average frost-free period of between 90-100 days with mean daily temperatures ranging from -16.7 to -17.8 in January to 18.9 in July. The average annual precipitation is 559mm. The second climatic region (4G - 2800 degree days, 102mm water deficiency and 305mm precipitation May to September) represents the area to the west and north of the first climatic zone. It is characterized by an average frost-free period of between 100 - 120 days with mean daily temperatures of -17.8 in January and +20 C. in July. The average annual precipitation is 508mm.

2.3 Soils and Topography

The Bedford Hills (319.2 - 395.2 meters asl., Smith et al., 1964) lies in the southern third of our study area, and represents a large upland area untouched by glacial Lake Agassiz. The topography is gently undulating and Whitemouth Lake divides the hills into two broad soil types. To the west, the soils are coarse textured and have good internal drainage. Soil types range from a Eutric Brunisol to a Grey Luvisol (Weir 1980). To the east of Whitemouth Lake, drainage is poor and the soils are organic fibrisols and mesisols.

The Bedford Hills are surrounded by water-modified glacial till. From the Hills east to the border lies a large expanse of flat wetlands, in which the average fall in elevation is less than 1m/km (Smith et al., 1964). Topography flattens to the south and natural drainage is poorly developed (Mill et al., 1977). The soils here are primarily organic fibrisols and mesisols (Weir 1980).

West of the Bedford Hills lies an area of level to undulating ground which together with improved drainage, aid in diversifying the soils (Smith et al., 1964). Much of this area is modified by agricultural and forestry management. A range of medium textured soils occur, from organic to gray luvisols (Weir 1980).

The northeast corner of our study site has many rock outcrops and is typical of shield terrain. The topography becomes increasingly hilly proceeding in a northeasterly direction (Weir, 1980). Soil types include dystic bunisols, and organic fibrisol and mesisols.

2.4 Vegetation

The southeastern sector of the study area has been classified as the Rainy River region by Rowe (1972). Much of this area is a mosaic of coniferous-deciduous associations which are a result of the frequent fires and selected logging practices. Vegetation type is found closely associated with soil type and drainage. Bogs and

fens occur in poorly drained sites conducive to peat accumulation, conditions which occur extensively throughout this area.

Bog vegetation consists typically of stunted black spruce (Picea mariana), tamarack (Larix laricina), leatherleaf (Chamaedaphne calyculata), and Sphagnum mosses. The ericoid shrub layer includes leather leaf and labrador tea (Ledum groenlandicum), bog laurel (Kalmia polifolia), bog rosemary (Andromeda spp.), and small cranberry (Oxycoccus microcarpus). Other herbs, forbs, and non-vascular plants include sedges (Carex and Scirpus spp.), cotton - grass (Eriophorum spp.), horsetails (Equisetum spp.), bog orchids (Habenaria spp.), bog mosses (Polytrichum spp.) and lichens (Cladonia spp.).

Fen vegetation poses a problem in classification. As pointed out in the previous report, fen types occur along successional gradients (Dixon and Stewart 1984). A general observation was that water levels are significant in determining fen types. Fens at the drier end of the spectrum are treed predominantly with tamarack, either scattered or in clumps, associated with ericoids, swamp birch (Betula glandulosa), grasses, and non-sphagnic mosses (Scorpidium spp.). As water deepens, vegetation shifts from graminoid treed fen to shrub fen, characterized by swamp birch, sedges (Carex spp.), and cotton-grass. At the wettest end of the gradient is the graminoid fen (Carex and Scirpus spp.) which has large pools of water visible

throughout the year. Exceptions to this generalized scheme are common. Visible pools of water may occur quite extensively in treed and shrubby fens, where the trees and shrubs grow on the tops of hummocks. As well, altered drainage, for example, caused by road construction, produce a surface vegetation often at variance to this generalized scheme.

Drier upland sites have greater floristic variability. The dominant tree species range from: well drained, pure stands of jack pine (Pinus banksiana), interrupted by the increasingly frequent red pine plantation (Pinus rugosa); to aspen forest with trembling aspen (Populus tremuloides), balsam poplar (P. balsamifera) and paper birch (Betula papyrifera); to damper sites, with mature stands of either white or black spruce or both.

3.0 METHODS

3.1 Vegetation Sampling

Several methods of vegetation sampling were employed because of the nature and scope of this project. A line transect and a fisheye lens were used to record the uppermost layer of visible vegetation represented from a bird's-eye-view. The uppermost layer of plant cover was considered to have the greatest influence upon spectral reflectance and emittance. A reléve method was used to

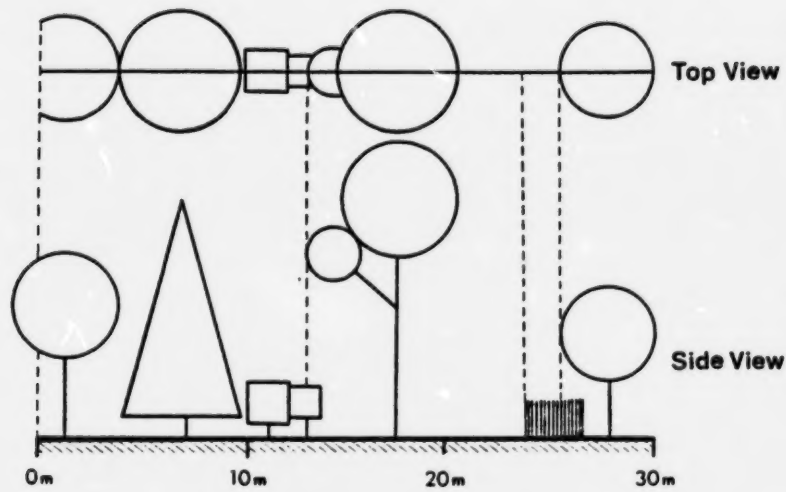
estimate the dominants and floristics of the plant community.

1. LINE TRANSECT - Within a designated vegetation type, the presence of plant species was recorded along a 30m tape. The cover of each plant was measured in centimeters at 1m intervals. The cover of each plant was determined by estimating the % of ground covered by the plant's foliage from a vertical viewing position (Fig. 2).

2. RELÉVE - Three 10m x 10m quadrats were sampled along each side of the line transect for a total of six quadrats (Fig. 3). Cover of each species was recorded as a number whose magnitude represented a range of percent cover values. The scale for each value was from a modified Braun-Blanquet system (adapted from Barbour (1980) (Appendix 1).

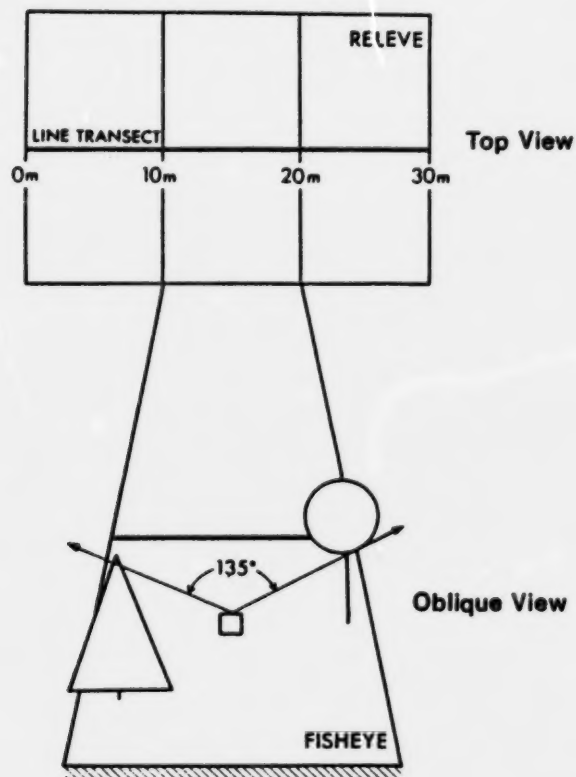
3. FISHEYE PICTURES - Vertical pictures were taken within the centre of each reléve, using a lens with a 135 degree field of view (Fig. 4). The negatives were analyzed using a Macbeth TR 527 densitometer, with an aperture of 2mm. Negatives were sampled using a grid work of 1/10 of an inch. The ratio of tree to sky cover was calculated using the density of pure sky and trees in relation to the average picture density.

FIGURE 2



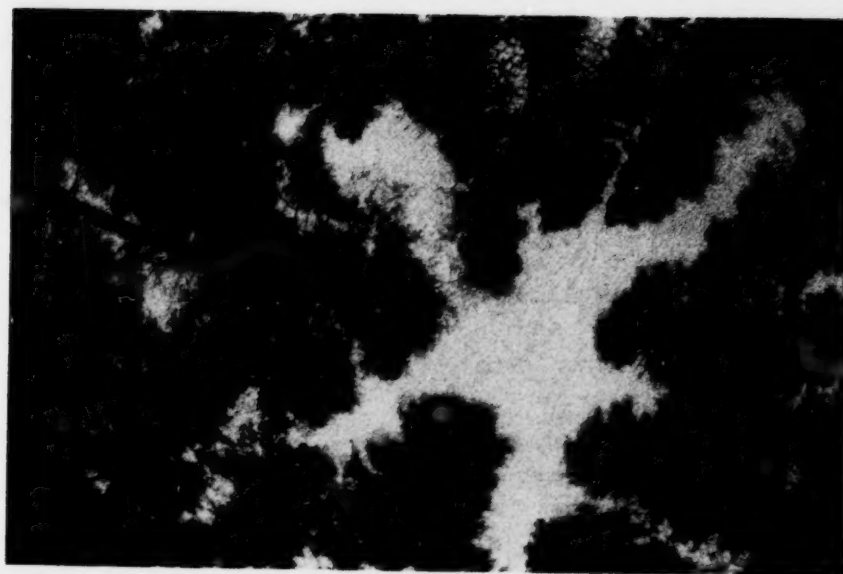
Graphical illustration of plant cover determined by line transect.

FIGURE 3



Reléves and fish-eye schematic for plant cover determination and the degree of canopy 'openness'

FIGURE 4



Fish-eye picture of black spruce canopy with
>75% closure

3.2 Cover Type Classification

3.2.1 Treed Bog

Bogs generally have closed drainage systems with precipitation the main external source of water. Soil water is acidic, often around pH 4.0, and nutrient poor. The bog class is characterized by a peat substrate, often Sphagnum - rich. Peat may reach depths of 6 meters (Bannatyne, 1980), however, many quality peat deposits have commercial grade peat seldom extending below 3 meters.

Two categories of treed bog were defined by the density of tree canopy cover and the abundance of water. Tree canopy cover ranges from a close contiguous cover of black spruce, to an open, discontinuous cover of stunted black spruce and tamarack (Fig. 5). Open areas in the treed bog with light canopy are dominated by such ericaceous shrubs as Chamaedaphne, Ledum, and Sphagnum mosses, and some swamp birch. Treed bog with open canopies have moderate amounts of pooled water.

3.2.2 Ericoid Bog

Within this bog class, black spruce and tamarack will occur only as isolated individuals (Fig. 6). The ericoid shrubs, such as Chamaedaphne, have the most widespread and dominant cover. Swamp birch is the most abundant non-ericoid. Beneath the shrub cover is a continuous surface layer of Sphagnum mosses with pools of water common

between hummocks.

FIGURE 5



Variability in
black spruce
canopy of Treed
Bog class.

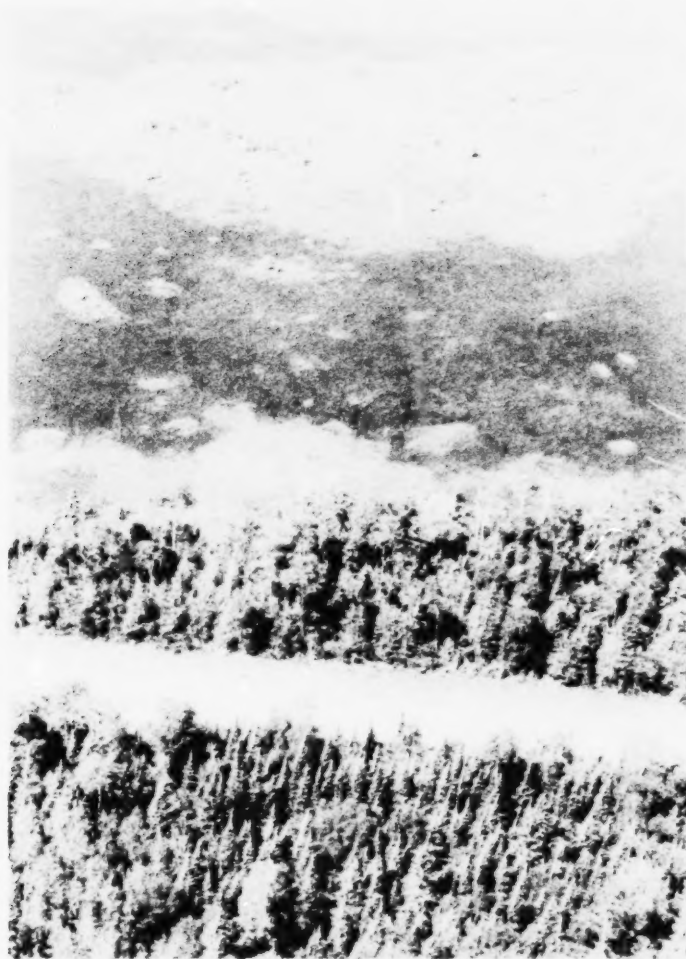


FIGURE 6

The ericoid bog class
surrounding treed bog
islands in the Caribou
Bog Cluster.

3.2.3 Graminoid - Rich Shrubby Fen

Fens are generally nutrient-rich wetlands with established patterns of runoff and drainage. The peat types found within fens are characterized by a high sedge content and fibre content with a watertable that remains at or near the surface throughout most of the year (Fig. 7)

Typical of the vegetation of graminoid-rich shrubby fens are low shrubs (less than 135 cm), grass and sedges, mosses, and scattered tamarack and black spruce. The shrubs are principally swamp birch, willows, and *Myrica gale* (sweet gale), with some leatherleaf. The topography is flat with occasional hummocks of mosses often around former tamarack and/or black spruce stumps. Standing water is most noticeable in the spring and early summer.

FIGURE 7



The rich shrubby graminoid class typical of the La Labre fen.

3.2.4 Graminoid-Rich Fen

Such fens have large graminoid areas often with open water and with or without islands of stunted trees (Fig. 8). Pools of water may persist throughout the growing season. Highly saturated fens in this class are characterized by sedges and may have some shrubs, eg. swamp birch, sweet gale, and willows which show reduced growth. Some of these sites border on a marsh-type environment. Former waterkill sites with high graminoid cover are included. Drier sites are characterized by high sedge litter, non-Sphagnum mosses, and more robust shrub cover growth.

FIGURE 8

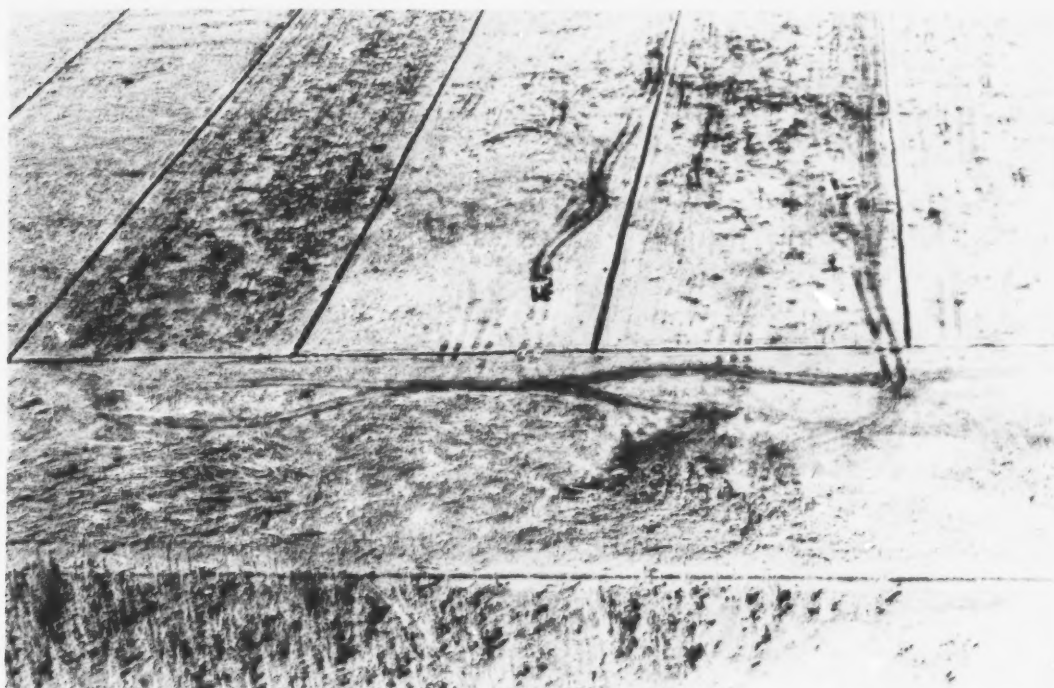


Graminoid-rich fen with islands of stunted black spruce and tamarack.

3.2.5 Peat Mining

Such areas represent the spectral reflectance from the exposed peat uncovered by mining or large farming operations (Fig. 9). All vegetation cover is removed, revealing a moist Sphagnum - rich peat moss which must be continuously tilled to accelerate drying by wind and sun.

FIGURE 9



Clearance on the new peat mining area of the Caribou Bog Cluster by Premier Moss Ltd.

3.2.6 Agriculture

This cover type contains all cultivated areas and pastures, primarily in mineral soils, whose man-made geometrical patterns on the landscape make identification easier.

3.2.7 Water

This category includes all lakes, rivers, and ponds of open water with areas greater than 1/4 hectare. All water bodies with depths greater than 1m. are included in this distinctive class.

3.2.8 Urban

The urban theme is easily distinguished by the small compact geometrical patterns which are always associated with transportation corridors. Few urban areas are located within the study area (Fig. 1).

3.3 Data Acquisition

Archival LANDSAT microfiche files were searched at the Manitoba Remote Sensing Centre to identify the most appropriate LANDSAT multispectral scanner (MSS) images for the study. The criteria for selection were: imagery had to be cloud free preferably at a date that coincided with the period of maximum vegetational growth and at a time when the sun elevation provided the greatest potential for ground

contrast in reflected radiation.

LANDSAT IV digital data were acquired from the following:

Track	Frame	Date
29	25 + 14 sec.	84-09-06
30	25 + 12 sec.	84-07-11

Reference data included aerial photographs, National Topographic Series (NTS) maps, vegetation sampling, and Bannatyne's (1980) study. Panchromatic aerial photography dated 1979-80 and 1970-71 provided coverage of the entire study area at a scale of 1:15840.

3.4 Data Analysis

Digital image analysis of the satellite data was achieved with the Applied Resource Image Exploitation System (ARIES-II). Image analysis operations were conducted in three stages (Figure 10). Stage one consisted of image preprocessing and included geometric corrections image to grid. Stage two resulted in classification of the satellite data. The third stage consisted of post classification filtering, manual theme assignments and the generation of output products.

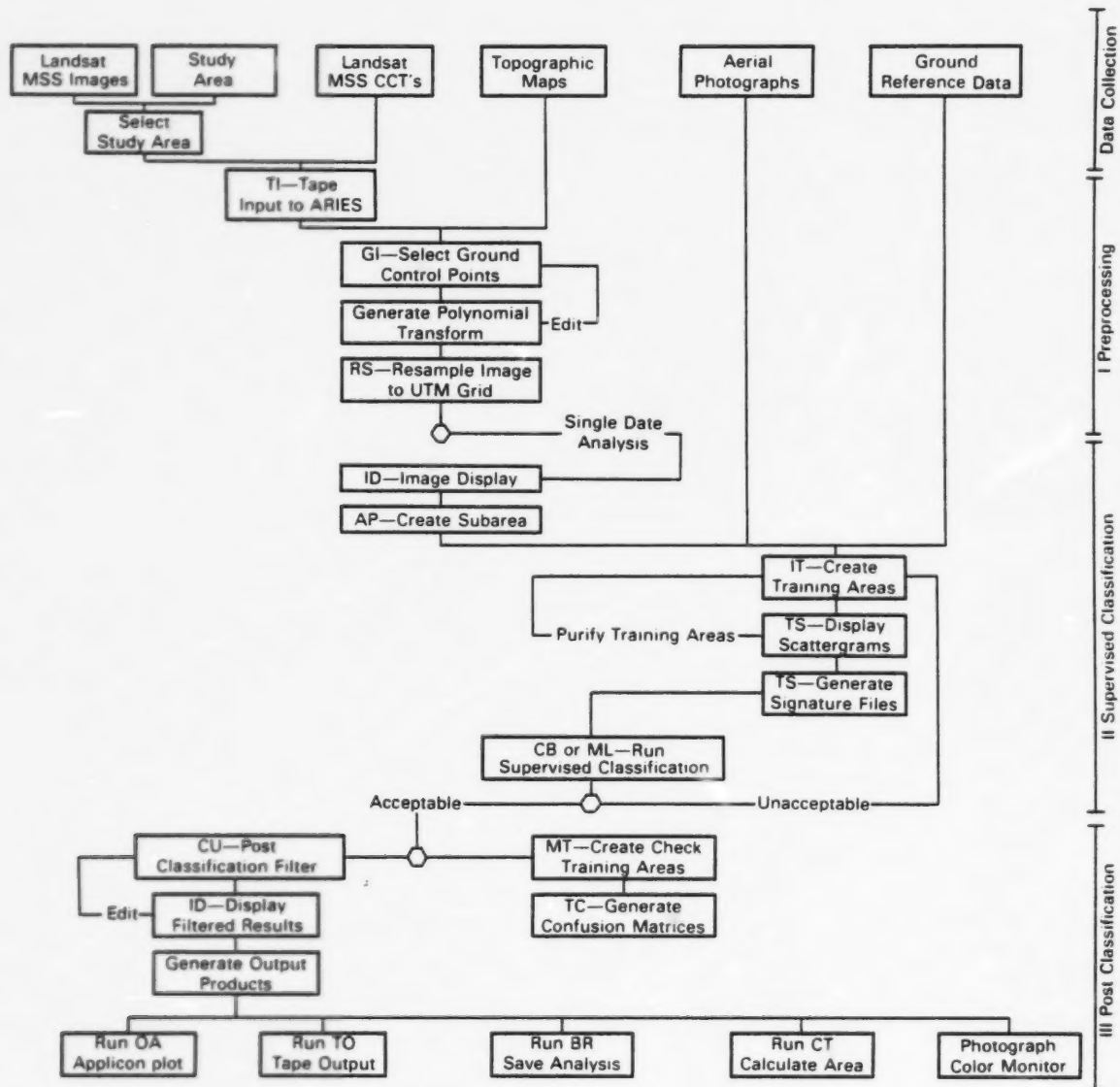


FIGURE 10 Flow chart of image analysis procedures followed on the ARIES—II image analysis system. Programs indicated by the two character identifiers are for version 2.1 of the All ASP software package.

3.4.1 Image Preprocessing

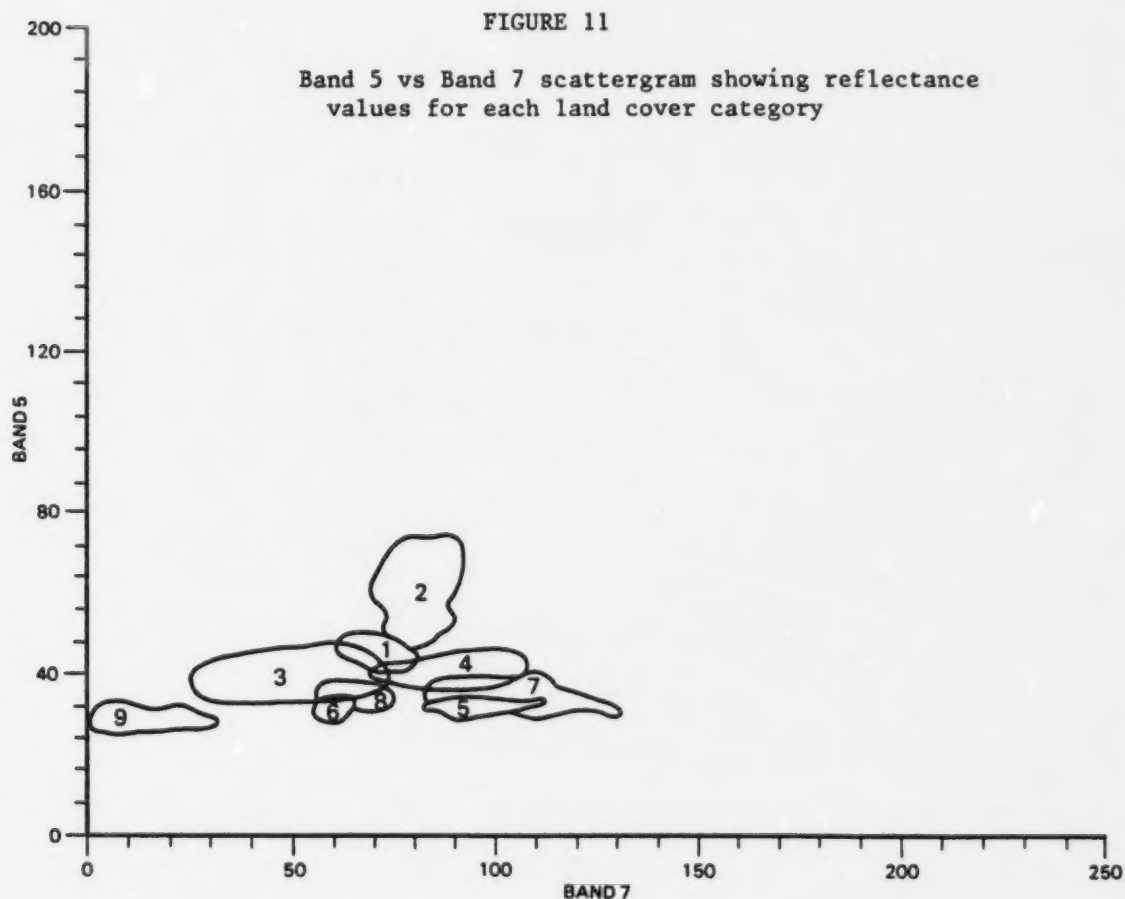
Image preprocessing consisted of image to Universal Transverse Mercator (UTM) grid registration. The first step in the image to grid registration was to generate a series of ground control points (GCP's). GCP's are points that were identified by their line/pixel coordinates on the satellite image and linked to corresponding northing/easting coordinates on the UTM grid system. The image transformation (change in image geometry) was achieved by a second order polynomial transformation.

The second step in the image to grid registration process was to generate a new image file by resampling an input file according to the parameters in the polynomial transform. The cubic convolution algorithm was used to resample each MSS band. In resampling from image to grid the standard 79m x 59m pixels were resampled to 80m x 80m.

3.4.2 Image Classification

Image classification involved a supervised method. Reference data, which included both ground and airphoto information were used to "train" the computer to recognize cover types of interest. All training areas that corresponded to one cover type formed a cluster. Each cluster represented a specific location in feature space and could be identified by their spectral coordinates. Scattergrams were used to display cluster data in Bands 5

(Y-axis) and 7(X-axis) (Figure 11). During the training, scattergrams were continually examined to ensure separability between clusters. When the training process was completed, theme statistics were computed. A maximum likelihood signature file was generated using the training area data. The signature file provided the statistical parameters that described the spectral characterization of each cover type.



- | | |
|-------------------------|---------------|
| (1) Shrub-Treed fen | (6) Jack Pine |
| (2) Marsh | (7) Deciduous |
| (3) Gramminoid-rich fen | (8) Conifers |
| (4) Treed Bog | (9) Water |
| (5) Mixedwood | |

A maximum likelihood classifier (Shlien and Goodenough 1973) was applied to the signature file. The classification results were stored in theme files which were displayed on the colour T.V. monitor for a visual assessment. Aerial photographs and bog data (Bannatyne, 1980) were used to assess the thematic data. Eighteen areas of the thematic data were checked in a non-decimated form for classification errors. If the results were unacceptable, modifications to the training areas were conducted.

3.4.3 Post Image Classification Analysis

Post image classification analysis included application of a minimum area filter and manual theme generation and an accuracy assessment. A minimum area filter was applied to the final classification to remove "noise" from the thematic data by replacing small areas with larger surrounding areas. The minimum size areas selected for the filter were based on visual comparison between classification results and ground reference data.

The manual theme program was used to correct known areas of misclassification as detected with reference data. When classification results were considered satisfactory, colour-coded thematic maps were generated.

The maps were then compared to panchromatic aerial photographs (1:15840), previously interpreted with the aid of field verification data. The area of a legal subdivision (16.18 ha) was used as a sampling unit. Sampling units were located on both the theme data of the map and the aerial photography. The classification of the unit was noted and recorded in the appropriate section of a contingency table (Table 1). The contingency table was then analyzed in two ways:

a) the proportion of the sampling units in a vegetation type will be uniquely represented by one colour on a thematic map (Table 2), and

b) the proportion of sampling units in a particular theme on the map was created by a specific vegetation type (Table 3).

Table 1 A Contingency Table of Sample Units from
Panchromatic Aerial Photography (1:15840)
to LANDSAT Thematic Maps

Aerial Photography (1:15840)

LANDSAT Theme	Treed Bog	Shrub Fen	Ericoid Bog	Sedge Fen	Other	Total
Dark Red	336	40	0	4	64	444
Pink	4	190	0	16	5	215
Yellow	0	0	22	0	5	27
Green	13	28	0	96	2	139
White (unclass.)	51	1	0	9	0	61
Total	404	259	22	125	76	886

Table 2 The Probability that a Wetland Type Will be
Uniquely Represented by One Colour

Vegetation Type	Number of Sampling Units	Proportion Correct	95% Confidence for Proportion
Treed Bog	404	0.832	0.795 - 0.868
Shrub Fen	259	0.734	0.680 - 0.787
Ericoid Bog	22	1.000	
Sedge Fen	125	0.768	0.694 - 0.842

Table 3 The Probability with which a Colour on Thematic
Map will Uniquely Represent Vegetation Type

Map Colour	Number of Sampling	Proportion	95% Confidence
	Units	Correct	for Proportion
Dark Red	444	0.757	0.717 - 0.797
Pink	215	0.884	0.841 - 0.927
Yellow	27	0.815	0.669 - 0.962
Green	139	0.691	0.614 - 0.767

4.0 RESULTS

4.1 Preprocessing

Two LANDSAT images were geometrically corrected on the ARIES-II. On average, 2.5 hours per band were required to resample 79m x 59m to 80m x 80m pixels. Six hours were also required to select GCP's, with a total computer time needed to correct the two images being 26.0 hours.

4.2 Image Classification

Six colour-coded thematic maps were produced for the study area at a scale of 1:125,000. The maps combined a LANDSAT spectral data background with a theme overlay consisting of wetlands, water and cultural features. Four wetland types were identified.

A total of 886 sampling units illustrated how the thematic maps compared to panchromatic aerial photography. The overall accuracy of the digital classification was 73%.

Tabulations from the six thematic map sheets are presented in Tables 1, 2, and 3.

4.3 Field Results

Primary cover values, representing a bird's-eye-view approach towards vegetation sampling, is recorded in Table 4. Site data was analyzed using cluster analysis and an ordination package (Decorana).

The analyses were unsatisfactory. Site data was arranged according to their thematic class. Species have been stratified into layers and ordered: trees, shrubs, ericaceous shrubs, herbs, and prostrate non-vascular plants. Non-biotic data was recorded last. Over 95% of the total cover was accounted for at most sites. This limit was set to reduce species number down for visual comparison. Any additional insignificant species would not greatly affect site recognition from the perspective of the satellite.

Complete botanical assemblages for each site are compiled in Appendix 1. Site and species arrangement are similar to that of Table 1. The six 10m x 10m quadrats have been simplified into one 20m x 30m quadrat. Each data point was averaged using the mean percentage cover. 'R' (rare), being insignificant was not added. The range for 'r' was arbitrarily chosen as any average percentage less than .05%.

4.5 Peat Depth Correlation

Peat depths for bogs in southeastern Manitoba were obtained from Bannatyne (1980) (Appendix 4). The variables chosen were a) bog clusters (groups of adjacent but physically separable bogs), b) individual bogs, c) maximum depth of peat with a minimum of 60% Sphagnum, and d) total depth of peat. The value of 60% Sphagnum was arrived at arbitrarily but which was thought to be of commercial importance. A fifth variable was the bog classes off the thematic maps (map Appendices 6-11). The analysis was

performed using an ANOVA stats package, University of Manitoba (Appendix 4). Numbers 1 and 2, are single interactions with the dependent variable. Number 3 is a multiple interaction with the dependent variable. The relationship column indicates whether there is a relationship between the dependent and independent variable.

5.0 DISCUSSION

The proportion of verified columns in Tables 2 and 3 indicate the success of isolating the various wetland classes. Table 2 represents the probability that a wetland type will be uniquely represented by one colour on a thematic map. All four types were represented by a particular colour with a mean proportion of 0.734 and greater.

Of the 404 Treed Bog sites sampled, 51 units (12.6%) remained unclassified (white). A total of 259 Shrub Fen sites were evaluated with the majority of the confusion (40) occurring with treed bog. Confusion occurred in the transition zone between these two classes. The Ericord bog sampled was not confused with any other class. Sedge fen was sampled with 125 units providing a mean proportion of 0.768. Confusion occurred with Shrub fen.

Table 3 represents the probability with which a colour on a thematic map will uniquely represent a vegetation type (Snedecor, 1967). Red, (Treed Bog) was sampled with 444

units providing a mean proportion of 0.757. Sixty-four units (14.4%) were confused with other (conifer forest) and 40 units (9%) with shrub fen. Pink (shrub fen) was sampled 215 times with some confusion (7%) occurring with sedge fen. Yellow (Ericoid Bog) was a very small class in terms of area, therefore the limited sampling units. Some confusion seems to occur with upland open areas (other).

Green representing sedge fen on the thematic maps was sampled with 139 units. The mean proportion was 0.691. Confusion occurs with shrub fen with 20.1% of the units and with another 9% of units classified as treed bog.

5.1 Limitations of Field Data

Although the line transect and reléve data remain important records of the vegetation, they are not valid for statistical testing. Sedge is present in all sites (Appendix 1). However, many species of sedges occur (Appendix 2), but are only statistically recognized as a single species. As well, no distinction was made between litter types. Litter has an additional problem in that it was not recorded in the first transects.

Seasonality has a multiple effect on sampling. Water table levels generally decrease after spring runoff, which may affect amounts of water reflectance. Also, seasonal changes in cover values result from plant growth. Shrubs were the slowest to become leafy, while sedges and mosses

greened early. The summer of 1985 was especially cold and wet with the resultant inhibition of growth.

There are limitations in all sampling techniques. High frequency species, like sedge, are difficult to quantify for density using the line transect. As well, tree cover was difficult to estimate using the line transect. An increase in accuracy for canopy cover was sought using a fish-eye-lens. A densitometer was used for the inspection of the picture negative, but the determination of the tree to sky ratio necessitates an accurate estimate of the density of 100% canopy and 100% sky cover. Sky densities were influenced by camera exposure, time of day, and the cloud cover, and 100% treed cover was not attainable because negative densities change depending upon the degree of branch over-lap. The analysis for negative density was not successful. Fish-eye pictures do have their value as visual aids.

The sampling area sought was one where large areas of uniform vegetation existed. Misclassification may have occurred in some sites not because of satellite error but because of the choice of the sampling site. The thematic class represents the average of the ground cover, whereas, the chosen site location may be representative of only part of a vegetation mosaic.

5.2 Discussion of Field Results

Vegetative classes through ground truthing, Table 5, support the LANDSAT thematic classification of peatlands. The surface reflectance of the four peatland classes are primarily represented by two to three dominant species types.

Treed bog cover is composed chiefly of black spruce (greater than 25%), labrador tea (4-14%), and Sphagnum mosses (0-42%).

The shrubby species *Chamaedaphne* (17 - 65%), and swamp birch (0 - 11%), as well as sedge (0 - 41%) and Sphagnum (15 - 40%) dominate cover in the ericaceous bog.

Graminoid - rich shrubby fen have swamp birch (0 - 33%), and sedge (2 - 58%) as dominant plant cover.

Sedges (4 - 62%) and their litter remains (0 - 78%) and moss species (0 - 47%), form the bulk of cover for the graminoid-rich fen.

In general, confusion was found only in 'borderline' communities. These communities exhibit characteristics of other classes of vegetation.

Sites 26 and 27 were unclassified because they did not meet the criteria of the four peatland classes. Site 27, for example, was initially classified under what was believed to be a third fen type. Confusion and overlap with other vegetation types led to the elimination of this undefined category. The decision did not detract from the

objective of this report.

Site 26 and 21 were a GSE type. However, they were unclassified because of their dryness and higher shrub (swamp birch 26%, site 26, and 39% total shrub cover for site 21), and litter cover (site 26, 41.7%, and site 21, 48.7%). Site 21 was manually classified early in the project.

CONCLUSIONS

A supervised classification was applied to LANDSAT-IV MSS imagery of the S.E. Manitoba in order to verify the spectral separability of commercially significant bog and fen classes. The spectral and spatial heterogeneity of vegetation cover types were used to generate peatland signatures for the S.E. Manitoba study area during the second stage of the peatland inventory of the province. Variability in peatland types was encountered during selected field surveys and analysis of previous data collected by Bannatyne (1980). Detailed botanical surveys and peat depth correlations were of limited value given the regional scale mapping being done. In terms of the time and money invested in the collection of ground reference information, additional research is needed to increase the efficiency and accuracy of interpreting the ecological meaning of information between the actual surface reflectance and the information recorded by the sensor. Such limitations in the application of multispectral and multitime data, nevertheless do increase along a detectable gradient defined by spectral, spatial and temporal resolutions. Accordingly from this study we predict that the confidence level for mapping the peatland themes range from Ericoid bog>Treed bog>Sedge fen>Shrub fen in terms of verification.

RECOMMENDATION

On the basis of the results from this project the following recommendations should be considered:

- a) Standardized procedures be adopted for multistage peatland inventories in this province, and where possible have such procedures compatible with those in other provinces.
- b) Enhanced colour images be used for preliminary stratification of the study region and initial selection of training areas.
- c) Supervised and multi-temporal classification be used to map the commercial size (>200h) bog and fen classes in the inventory map of the study area.

REFERENCES

1. Bannatyne, B., 1980. Sphagnum Bogs in Southern Manitoba and Their Identification by Remote Sensing. Economic Geology Report ER79-7. Manitoba Department of Energy and Mines, Winnipeg. 103p.
2. Barbour M., Burk J. and W. Pitts, 1980. Terrestrial Plant Ecology. Benjamin Cummings Publishing Co., California. 604p.
3. Dixon, R. and J. Stewart, 1984. Peatland Inventory of Manitoba I - The Pas Using LANDSAT. Manitoba Remote Sensing Centre, Department of Natural Resources. TR84-5, 32p.
4. Heinzelman, M. 1970. Landscape Evolution, Peatland Types and the Environment in the Lake Agassiz Peatland Natural Area. Minnesota. Ecol. Monogr. 40: 235-261.
5. Mills, G., L. Hopkins and R. Smith, 1977. Organic Soils of the Rosseau River Watershed in Manitoba. Inventory and Assessment for Agriculture. Manitoba Soil Survey Monograph No. 17.
6. Mollard J., and J. Janes, 1984. Airphoto Interpretation and the Canadian Landscape. Ch. 7 in Permafrost and Peatland Terrain. Canadian Department of Energy, Mines and Resources, Ottawa. 415p.
7. Pala, S., 1982. A Method of Peatland Inventory Based on LANDSAT and Computerized Mapping. Proceedings, Symposium on

- Peat and Peatlands, Shippigan, N.B. CNC-IPC 266-290p.
8. Pala, S., 1983. A LANDSAT-Based Method for the Survey and Inventory of Peat Resources over Extensive Regions. Proceedings, Symposium of IPS Commission 1. Aberdeen, Scotland, September 12-15, 156-168p.
 9. Palylyk, C., 1985. LANDSAT MSS Digital Data for Peatland Inventory. M.Sc. Thesis. University of Alberta. Department Soil Science, Edmonton. 144 p.
 10. Radforth, N., 1969. Airphoto Interpretation of Muskeg. In I. MacFarlane (ed) Muskeg Engineering Handbook, U. of Toronto Press, 55 - 77p.
 11. Rowe, J. 1972. Forest Regions of Canada. Department of Environment. Canada Forestry Service Publication 1300. 172p.
 12. Shlien S. and D. Goodenough, 1973. Automatic Interpretation of ERTS-A Imagery Using the Maximum Likelihood Decision Rule. C.C.R.S. Department Energy, Mines and Resources, Ottawa. Research Report 73-2, 22p.
 13. Smith, R., W. Ehrlich, J. Jameson, and J. Cayford, 1964. Soil Survey of the Southeastern Map Sheet Area. Manitoba Department of Agriculture. Soils Report No. 14.
 14. Stove, C., 1983. Improved Peatland Classification Using PCA based on Synthetic Variables: A Remote Sensing Methodology for Peat Resource Surveys in Scotland. Proceedings, Symposium

of IPS Commission 1. Aberdeen, Scotland, September 22-25.
65-74p.

15. Tarnacoi, C. and J. Stewart, 1986. Peatland and Organic Soil Inventories in Canada. NRCC Proceedings 'Advances in Peatland Engineering' Carleton University, Aug. 25-26. 61-71p.
16. Tarnacoi, C., 1970. Classification of Peat Landforms in Manitoba. Canada. Department of Agriculture. Research Station. Pedology Unit, Winnipeg. 45p.
17. Tarnacoi, C., 1974. Peat Landforms and Associated Vegetation in Manitoba. Proceedings, C.S.S.C. Organic Soil Mapping Workshop. Winnipeg. 73p.
18. Weir, T. ed. 1980. Atlas of Manitoba. D. W. Friesen & Sons, Ltd., Altona, Manitoba. 157 p.
19. Zoltai, S., F. Pollett, J. Jeglum and G. Adams, 1972. Developing a Wetland Classification for Canada. Proceedings, 4th North American Forest Soils Conference, Quebec, Laval University. 497-511p.

APPENDIX 1 - BOTANICAL ASSEMBLAGES AT SAMPLING SITES.

Plant cover within each site has been estimated using a modified form of the Braun-Blanquet system (Barbour, 1978). Vegetative classes are defined using the symbols: TB (treed bog), EB (ericaceous bog), GSF (graminoid-rich shrubby fen), GF (graminoid-rich fen), and UC (unclassified). Taxa are grouped according to vertical stratification (eg. trees, shrubs, ericaceous shrubs, herbs, and non-vasculars). The number of vascular and non-vascular taxa is n=94. Site locations are found in the appended maps. Sampling dates are found in table 5.

	Variable						% Cover						Mean % Cover					
	5	4	3	2	1	t	75-100	50-75	25-50	5-25	1-5	<1	87.5	62.5	37.5	15.0	2.5	insig.
	TB						EB						GSF					
Site Number	14	9	7	22	18	24	1	10	5	11	8	6	21	13	3	19	17	12
	15	20	23	4	2	16	25	27	26									
<i>Picea mariana</i>	5	4	4	t	2	2		t	2	r	r	t						
<i>Larix laricina</i>			t	3		1	2	t	1	r	r	t						
<i>Populus balsamifera</i>				t														
<i>Betula glandulosa</i>			t	t			3	1	1	2	2	1	2	2	3	2	r	
<i>Salix</i> spp.			r	1	1		r						r	2	t	t	3	
<i>Myrica gale</i>				3									2					
<i>Alnus</i> spp.				r	2		2						r		r	r		
<i>Rhamnus</i> spp.					r													
<i>Lonicera</i> spp.				t	2													
<i>Cornus</i> spp.	r			r														
<i>Ledum groenlandicum</i>	2	3	3	2	2	t	r	2										
<i>Chamaedaphne calyculata</i>			2			2	1	3	4	3	3	3						
<i>Andromeda glaucophylla</i>			t	r				r	2		2	3						
<i>Kalmia polyfolia</i>						1		r	2			3						
<i>Vaccinium vitis-idaea</i>	r	t	1		r			r	1			2						
<i>Oxycoccus microcarpus</i>			t	r	r	r		r	2		r	2						
Sedge *	t		t	r	1	1	r	t	2	1	2	3	1	4	5	2	2	2
<i>Equisetum</i>	r			r				r					r	r	1	1		
<i>Cornus canadensis</i>	1			r	t													
<i>Smilacena stellata</i>	r																	
<i>Maianthemum canadense</i>	t																	
<i>Trientalis borealis</i>	1			r	r													
<i>Ribes</i> spp.				r	r													
<i>Petasites palmatus</i>	r																	
<i>Anemone quinquefolia</i>	r																	
<i>Rosa</i> spp.	r																	
<i>Smilacena trifolia</i>				r	t													
<i>Petasites sagittatus</i>				r	r													
<i>Sarracenia purpurea</i>						r												
<i>Menyanthes trifoliata</i>																		
<i>Rubus acaulis</i>	t			t	t													
<i>Galium labradoricum</i>																		
<i>Campanula apperina</i>																		
<i>Triglochin maritima</i>																		
<i>Potamogeton natans</i>																		
<i>Solidago</i> spp.																		
<i>Drosera</i> spp.						r												
<i>Viola</i> spp.						r												
<i>Aurethusa crispa</i>																		
<i>Parnassia</i> spp.																		
<i>Lobelia kalmii</i>																		
<i>Dracopis</i> spp.																		
<i>Scirpus acutus</i>																		
<i>Calla palustris</i>							t											
<i>Potentilla palustris</i>																		
<i>Phragmites communis</i>			r															
<i>Typha</i> spp.							t											
<i>Hypericum virginicum</i>																		
<i>Naumburgia tristiflora</i>																		
<i>Scutellaria galericulata</i>																		
<i>Iris versicolor</i>																		
<i>Sphagnum</i> spp.	2	2	4	2	4	4	r	4	3	3	2	3	1	3	4	t	2	2
Other mosses	3	3	2		r	r	t	1				1						2
Lichen spp.			t															
Litter	1			3	2								3	2	2	4		5
Water	r	t		t	3			t	1	1	1	2	1	1	3		3	1

* see appendix 2 for a listing of sedge species per site
 n manually classified

APPENDIX 2 - A Partial List of
Site Grass and Sedge Species

Site 2	Carex livida	Site 16	Carex aquatilis
3	Carex livida	17	Calamagrostis inexpansa
	Eriophorum spissum		Eriophorum chammissonis
11	Eriophorum spissum	18	Carex diandra
			C. gynocrates
			C. lasiocarpa
12	Calamagrostis neglecta		C. rostrata
	Carex lasiocarpa		
	C. aquatilis	19	Calamagrostis neglecta
	Eriophorum scheuchzer		Carex interior
			C. lacustris
13	Carex buxbaumii		Eleocharis elliptica
	C. chordorrhiza		Eriophorum gracile
	C. diandra		
	C. limosa		
	C. livida	20	Eriophorum chammissonis
	Eriophorum chammissonis		Scirpus caespitosus
	E. viridi-carinatum		
15	Carex livida	21	Eriophorum sp.
	Calamagrostis neglecta		
	Eleocharis elliptica	22	Eriophorum sp.
	Eriophorum angustifolium		
	Glyceria striata	23	Scirpus caespitosus
	Scirpus caespitosus		

Scirpus hudsonianus

25 *Carex aquatilis*

Cladium mariscoides

Eriophorum chammissonis

Scirpus acutus

26 *Eriophorum chammissonis*

27 *Carex buxbaumii*

Deschampia caepitosa

Eleocharis elliptica

Scirpus validus

APPENDIX 3

Peat Depths - Anova ($\alpha=.5$)

Dependant Variable	Independent Variable	PR F	Hypothesis Accepted/Rejected
Total Peat	Bog Cluster	.0001	A
Depth	Map Theme	.9106	R
Sphagnum 60%	Bog Cluster	.0001	A
	Map Theme	.4026	A
Total D	Site	.0001	
	M. Theme	.8665	
	Both	.0001	
Sphagnum 60%	Site	.0001	
	Map Theme	.1561	
	Both	.0001	
Total Peat	Bog Cluster	.0001	A
Depth	Map Theme	.8370	
Sphagnum 60%	Bog Cluster	.0001	
	Map Theme	.1050	
Total D.	Site	.0001	
	Map Theme	.8070	
	Both	.0001	
Sphagnum 60%	Site	.0001	
	Map Theme	.0662	
	Both	.0001	

APPENDIX 4

Peat Depths, Summarized from Bannatyne
(1980), of Some Major Bogs Found in
the Study Area

Column 2 - Bog Clusters - MID (Middlebro), WLS (Whitemouth
Lake South), NWA (Northwest Angle), CC (Caribou cluster),
and POW (Powawassan).

Column 3 - Individual bogs found within bog clusters.

Column 4 - Vegetation class according to map sheets -
1 - closed treed bog; 2 - open treed bog;
3 - Ericoid bog.

Column 5 - Peat depth in metres with Sphagnum > 60%.

Column 6 - Peat depth in metres.

Peat Depths - Summarized from Bannatyne (1980)

Column

1	2	3	4	5	6	
1.	MID	MID	1	3	0.0	2.4
2.	MID	MID	2	1	2.0	2.7
3.	MID	MID	3	1	2.5	2.85
4.	MID	MID	4	2	1.5	2.5
5.	WLS	WLS	5	1	0.0	1.95
6.	WLS	WLS	6	2	0.0	1.9
7.	WLS	WLS	7	2	1.5	2.7
8.	WLS	WLS	8	3	0.0	2.45
9.	WLS	WLS	9	3	0.0	2.85
10.	WLS	WLS	10	2	0.0	1.9
11.	WLS	WLS	11	2	0.0	2.5
12.	WLS	WLS	12	2	0.0	2.5
13.	NWA	NWA	13	1	1.5	2.55
14.	NWA	NWA	14	2	2.0	3.35
15.	NWA	NWA	15	1	1.0	2.4
16.	NWA	NWA	16	2	0.0	2.15
17.	NWA	NWA	17	3	0.0	1.9
18.	CC	CSE	18	2	3.0	3.7
19.	CC	CSE	21	2	3.7	3.8
20.	CC	CSE	23	3	3.0	3.9
21.	CC	CSE	24	2	2.0	3.0
22.	CC	CSE	26	2	2.5	4.0
23.	CC	CSE	27	2	3.85	4.0
24.	CC	CSE	28	2	3.0	4.0
25.	CC	CSE	29	1	3.5	3.95
26.	CC	CSE	30	3	0.0	3.5
27.	CC	CSE	31	3	3.0	3.25
28.	CC	CSE	32	2	4.0	4.8
29.	CC	CSE	33	2	4.0	4.8
30.	CC	CSE	34	1	4.5	4.8
31.	CC	CSE	35	1	4.5	5.0
32.	CC	CSE	36	3	4.0	4.8
33.	CC	CSE	37	2	3.0	3.4
34.	CC	CSE	38	2	4.0	4.4
35.	CC	CSE	39	3	4.5	5.0
36.	CC	CSE	40	2	4.5	4.8
37.	CC	CSE	41	3	2.5	4.85
38.	CC	CSE	42	1	4.0	5.0
39.	CC	CSE	43	2	4.5	5.0
40.	CC	CSE	44	3	4.5	5.0
41.	CC	CSE	45	2	4.0	4.85
42.	CC	CSE	46	2	1.5	3.5
43.	CC	CSE	47	3	1.0	3.5
44.	CC	CS	48	2	1.0	2.5
45.	CC	CS	49	3	2.0	3.4
46.	CC	CS	50	3	3.0	4.0
47.	CC	CS	51	3	3.0	4.85
48.	CC	CS	52	3	2.0	4.5
49.	CC	CS	53	3	1.0	4.0
50.	CC	CS	54	3	2.0	5.0
51.	CC	CS	55	3	2.0	5.0
52.	CC	CS	56	2	1.0	4.4
53.	CC	CS	57	2	2.0	4.8
54.	CC	CS	58	2	3.7	5.5
55.	CC	CS	59	2	5.3	5.4
56.	CC	CS	60	2	4.0	5.85
57.	CC	CS	61	2	4.0	5.35
58.	CC	CS	62	3	3.0	4.7
59.	CC	CS	63	3	2.0	4.95
60.	CC	CS	64	3	3.0	4.2
61.	CC	CS	65	2	4.0	5.0
62.	CC	CS	67	2	5.0	5.85
63.	CC	CS	68	2	4.0	5.0
64.	CC	CS	69	3	4.0	5.0

Column

1	2	3	4	5	6
65.	CC	CS—70	2	4.5	5.0
66.	CC	CS—71	3	4.0	5.0
67.	CC	CS—72	3	4.0	5.0
68.	CC	CS—73	2	5.0	5.0
69.	CC	CS—74	2	4.5	5.0
70.	CC	CS—75	3	3.5	4.85
71.	CC	CS—76	2	4.0	5.0
72.	CC	CS—79	3	4.0	5.0
73.	CC	CS—81	3	3.0	4.75
74.	CC	CS—82	2	4.0	5.0
75.	CC	CS—83	2	4.0	5.05
76.	CC	CS—84	2	4.0	5.5
77.	CC	CS—85	3	4.0	5.55
78.	CC	CS—86	3	4.0	5.3
79.	CC	CS—87	2	4.85	5.2
80.	CC	CS—88	2	5.0	5.3
81.	CC	CSW—89	2	3.5	4.1
82.	CC	CSW—90	1	4.0	4.5
83.	CC	CSW—91	2	4.0	5.0
84.	CC	CSW—92	3	4.5	4.85
85.	CC	CSW—93	2	3.5	5.0
86.	CC	CSW—94	2	4.5	5.2
87.	CC	CSW—95	1	3.0	5.0
88.	CC	CSW—96	3	3.5	4.5
89.	CC	CSW—97	3	4.5	5.0
90.	CC	CSW—98	3	3.0	3.73
91.	CC	CSW—99	2	2.0	4.25
92.	CC	CNE—101	2	1.5	3.9
93.	CC	CNE—102	2	2.5	4.2
94.	CC	CNE—103	2	2.0	3.3
95.	CC	CNE—104	2	3.0	3.5
96.	CC	CNE—105	1	3.5	4.5
97.	CC	CNE—106	2	3.0	4.55
98.	CC	CNE—108	2	2.5	4.5
99.	CC	CNE—110	3	4.0	4.5
100.	CC	CNE—111	2	1.0	2.5
101.	CC	CNE—112	2	2.0	2.8
102.	CC	CNE—113	2	2.0	3.35
103.	CC	CNE—114	2	3.0	5.0
104.	CC	CNE—115	1	3.0	3.5
105.	CC	CNE—116	1	2.0	3.0
106.	CC	CNE—117	3	1.5	4.95
107.	CC	CNE—118	3	3.0	4.85
108.	CC	CNE—119	3	3.5	4.95
109.	CC	CNE—120	2	3.5	4.5
110.	CC	CNE—121	2	2.5	4.5
111.	CC	CNE—122	1	3.0	3.5
112.	CC	CNE—123	2	1.0	1.9
113.	CC	CNE—124	3	0.5	0.6
114.	CC	CNE—125	1	2.0	2.85
115.	CC	CNE—126	2	1.0	2.0
116.	CC	CNE—127	1	2.0	2.35
117.	CC	CNW—128	2	4.0	4.45
118.	CC	CNW—129	2	1.5	2.4
119.	CC	CNW—130	2	2.0	2.7
120.	POW	PSW—131	3	0.0	3.1
121.	POW	PSW—132	2	3.5	3.9
122.	POW	PSW—134	3	1.5	3.4
123.	POW	PSW—135	2	3.0	3.6
124.	POW	PC—136	2	1.5	2.35
125.	POW	PC—139	3	0.75	2.85
126.	POW	PW—140	3	2.5	3.85
127.	POW	PW—141	2	3.0	4.1
128.	POW	PE—143	2	1.3	2.35

129.	POW	PE	129	2	2.0	3.5
130.	STL	STL	130	2	2.5	3.15
131.	STL	STL	131	2	2.0	4.2
132.	STL	STL	132	2	2.0	3.7
133.	STL	STL	133	2	2.0	3.5
134.	STL	STL	134	2	2.0	4.0
135.	STL	STL	135	2	1.0	2.75
136.	STL	STL	136	2	1.5	2.75

APPENDIX 5

Floristic List of Species Identified

Division PTERIDOPHYTA

EQUISETACEAE (HORSETAIL FAMILY)

- | | |
|-----------------------|-----------------------------------|
| *Equisetum fluviatile | Water-Horsetail (Swamp horsetail) |
| *E. palustre | Marsh-Horsetail |
| *Equisetum spp. | |

POLYPODIACEAE

- | | |
|-----------------------|-----------------------|
| *Dryopteris austriaca | Spinulose shield fern |
|-----------------------|-----------------------|

Division SPERMATOPHYTA

Subdivision ANGIOSPERMAE (Angiosperms)

Class MONOCOTYLEDONEAE

ARACEAE (Arum Family)

- | | |
|------------------|------------|
| *Calla palustris | Water Arum |
|------------------|------------|

CYPERACEAE (Sedge Family)

- | | |
|------------------|---------------------|
| *Carex aquatilis | water sedge |
| *C. buxbaumii | brown sedge |
| *C. chordorrhiza | prostrate sedge |
| *C. diandra | two-stamened sedge |
| *C. gynocrates | northern bog sedge |
| *C. lacustris | lakeshore sedge |
| *C. lasiocarpa | hairy-fruited sedge |

*C. limosa	mud sedge
*C. livida	livid sedge
*C. interior	inland sedge
*C. prairea	prairie sedge
*C. rostrata	beaked sedge
*Cladium mariscoides	twig rush
*Eleocharis elliptica	slender spike-rush
*Eriophorum angustifolium	tall, cotton-grass
*E. chamissonis	russet cotton-grass
*E. gracile	slender cotton-grass
*E. scheuchzeri	one-spike cotton-grass
*E. spissum	sheathed cotton grass
*E. viridi-carinatum	thin-leaved cotton-grass
*Scirpus acutus	Hard Stem Bulrush
*S. caespitosus var.*callosus	Bulrush (tufted bulrush)
*S. hudsonianus	alpine cotton-grass
*S. validus	great bulrush

GRAMINEAE (Grass Family)

*Bromus ciliatus	fringed brome
*Calamagrostis inexpansa	northern reed grass
*C. neglecta	narrow reed grass
*Deschampsia caespitosa	tufted hair grass
*Glyceria striata	fowl manna grass
*Phragmites communis	giant reed grass

JUNCAGINACEAE (Arrow-grass Family)

*Triglochin maritima	seaside arrow-grass
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LILIACEAE (Lily Family)

**Smilacina trifolia* three-leaved Solomon's seal

ORCHIDEACEAE (Orchis Family)

**Arethusa bulbosa* dragon's-mouth

ZOSTERACEAE (Pondweed Family)

**Potamogeton natans*

Class DICOTYLEDONEAE

BETULACEAE (Birch Family)

**Alnus crispa* Syn: *A. viridis* Alder (green alder)

**Betula glandulosa* Syn: *B. Nana* Dwarf Birch (scrub birch)

CAMPANULACEAE (Bluebell Family)

**Campanula aparinoides* Marsh-Bluebell

**Lobelia kalmii* Kalm's lobelia

CAPRIFOLIACEAE (Honeysuckle Family)

**Lonicera villosa* Syn: *L. Caerulea* Mountain-Fly-Honeysuckle
Blue fly honeysuckle

**L. dioica* Twining honeysuckle

**L. oblongifolia* Swamp-Fly-Honeysuckle

COMPOSITAE

**Petasites sagittatus* arrow-leaved colt's foot

**Solidago* spp. Goldenrod

CORNACEAE (Dogwood Family)

**Cornus canadensis* Bunchberry

**C. stolonifera* Syn: *C. alba* red-osier dogwood

DROSERACEAE (Sundew Family)

**Drosera linearis* slender-leaved sundew

**D. rotundifolia* Round-leaved sundew

ERICACEAE (Heath Family)

**Andromeda glaucophylla* Bog-rosemary

**A. polifolia*

**Chamaedaphne calyculata* Leather-leaf

**Kalmia polifolia* Bog-laurel

**Ledum groenlandicum* Labrador-tea

VACCINIACEAE (Huckleberry Family)

**Oxycoccus microcarpus* Small cranberry

**O. quadripetalus* swamp cranberry

**Vaccinium angustifolium* Low sweet blueberry

**V. myrtillus* whortleberry

**V. uliginosum* Bog whortleberry

**V. vitis-idaea* dry ground cranberry

GENTIANACEAE (Gentian Family)

**Menyanthes trifoliata* bogbean

GUTTIFERAE (St. John's-wort Family)

**Hypericum virginicum* Marsh St. John's-wort

LABIATAE

**Mentha arvensis* field mint

**Dracocephalum parviflorum* American dragonhead

MYRICACEAE (Wax-Myrtle Family) (Bayberry Family)

*Myrica gale sweet Gale

ONAGRACEAE (Evening-Primrose Family)

*Epilobium angustifolium fireweed

PINACEAE

*Larix laricina Tamarack

*Picea mariana Black Spruce

PRIMULACEAE (Primrose Family)

*Trientalis borealis northern star flower

*Naumburgia thyrsiflora or Tufted Loosestrife
Lysimachia thyrsiflora

RANUNCULACEAE (Crowfoot Family)

*Ranunculus spp.

RUBIACEAE (Madder Family)

*Galium labridoricum (bed straw)

ROSACEAE (Rose Family)

*Potentilla fruticosa Shrubby Cinquefoil

*P. palustris marsh cinquefoil

*Rubus acaulis stemless raspberry

*R. pubescens dewberry

SALICACEAE (Willow Family)

*Populus balsamifera balsam poplar

*Salix pedicellaris bog willow

*Salix spp. willow

SARRACENIACEAE (Pitcher-Plant Family)

**Sarracenia purpurea* Pitcher-Plant

SAXIFRAGACEAE (Saxifraga Family)

**Parnassia* spp. Grass-of-Parnassus

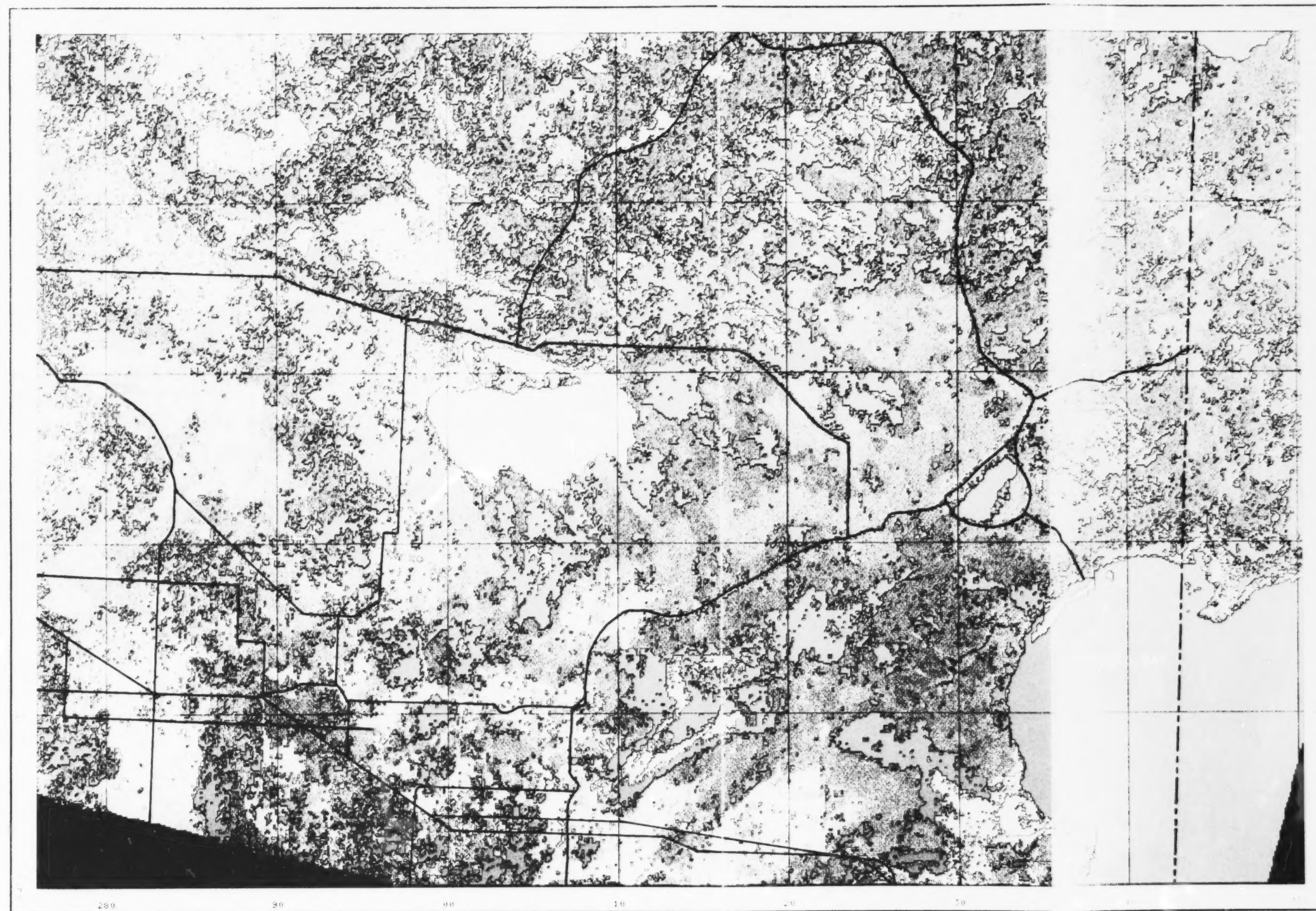
**Ribes hirtellum* Syn: *R. oxycanthoides* (northern gooseberry)

**R. triste* Syn: *R. rubrum* (swamp red current)

VIOLACEAE (Violet Family)

**Viola* spp.

APPENDIX 6



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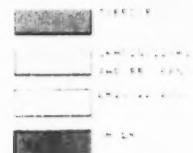
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